

THE ECONOMIC ADVANTAGES OF THE USE OF PREFABRICATION TECHNOLOGY BY DEVELOPERS IN THE POLISH HOUSING MARKET

EKONOMICZNE ZALETY WYKORZYSTANIA TECHNOLOGII PREFABRYKACJI PRZEZ DEWELOPERÓW NA POLSKIM RYNKU MIESZKANIOWYM

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Abstract: Real estate development activity, dependent on the construction market, is characterized by a long implementation time, delays resulting from climatic seasonality, and a long period for which the invested capital is tied up when traditional construction methods are used. Therefore, more efficient construction methods should be sought. One of them is considered to be modern prefabrication. The article aims to check whether Polish developers operating in the housing market use modern prefabrication to improve the construction process and what the economic benefits of using this technology can be achieved. Using desk research and case-study methods, the author has demonstrated that prefabrication in Polish multi-family housing is not yet popular, but it seems necessary to promote it because of its rather positive impact on real estate development activity in the housing market, which is manifested mainly in shorter project implementation times.

Keywords: real estate development activity, housing market, construction market, prefabrication

Abstrakt: Działalność deweloperska, zależna od rynku budowlanego, charakteryzuje się długim czasem realizacji, opóźnieniami wynikającymi z sezonowości klimatycznej oraz długim okresem zamrożenia zainwestowanego kapitału przy zastosowaniu tradycyjnych metod budowlanych. Powinno się zatem poszukiwać bardziej efektywnych metod budowy. Za jedną z nich uznaje się współczesną prefabrykację. W związku z tym celem artykułu jest sprawdzenie, czy polscy deweloperzy działający na rynku mieszkaniowym wykorzystują współczesną prefabrykację do usprawnienia procesu budowlanego oraz jakie korzyści ekonomiczne wynikają z zastosowania tej technologii w budownictwie w Polsce. Wykorzystując metody *desk research* i *case study* wykazano, że prefabrykacja w polskim budownictwie wielorodzinnym nie jest jeszcze popularna, ale konieczne wydaje się jej propagowanie, ponieważ ma raczej pozytywny wpływ na aktywność deweloperską na rynku mieszkaniowym, przejawiający się głównie krótszym czasem realizacji projektów.

Słowa kluczowe: działalność deweloperska, rynek mieszkaniowy, rynek budowlany, prefabrykacja

Introduction

During the communist era in Poland, there was no free real estate market, and state property, established through nationalization processes, dominated in construction activity (Załączna, 2010). The State took on the obligation of meeting housing needs of citizens, the gap between needs and supply, however, was enormous (in 1960, the number of dwellings per 1,000 inhabitants was 236, and in 1988 only 290; Kucharska-Stasiak et al., 2020). Then, in order to quickly increase the size of the housing stock, technology based on prefabricated elements (named in this article "old prefabrication") was used. Unfortunately, in many cases, technical defects related to both building materials and the quality of workmanship were

found in buildings constructed in Poland (Stangierski, Walewicz, 1984). For this reason, old prefabrication (until 90's) gained a bad reputation, and in the 1990s, following the introduction of the market economy, improved traditional technology, which is more time-consuming (about 22 months is needed to build a multi-family building – Statistics Poland, accessed: July 2020) gained a foothold. The problem, however, is that there is still a significant shortage of housing in Poland (the number of rooms per person is one of the smallest in Europe – see: Figure 1), especially of the affordable housing, and the existing dwellings are often overcrowded (nearly 37% of dwellings in Poland in 2020).

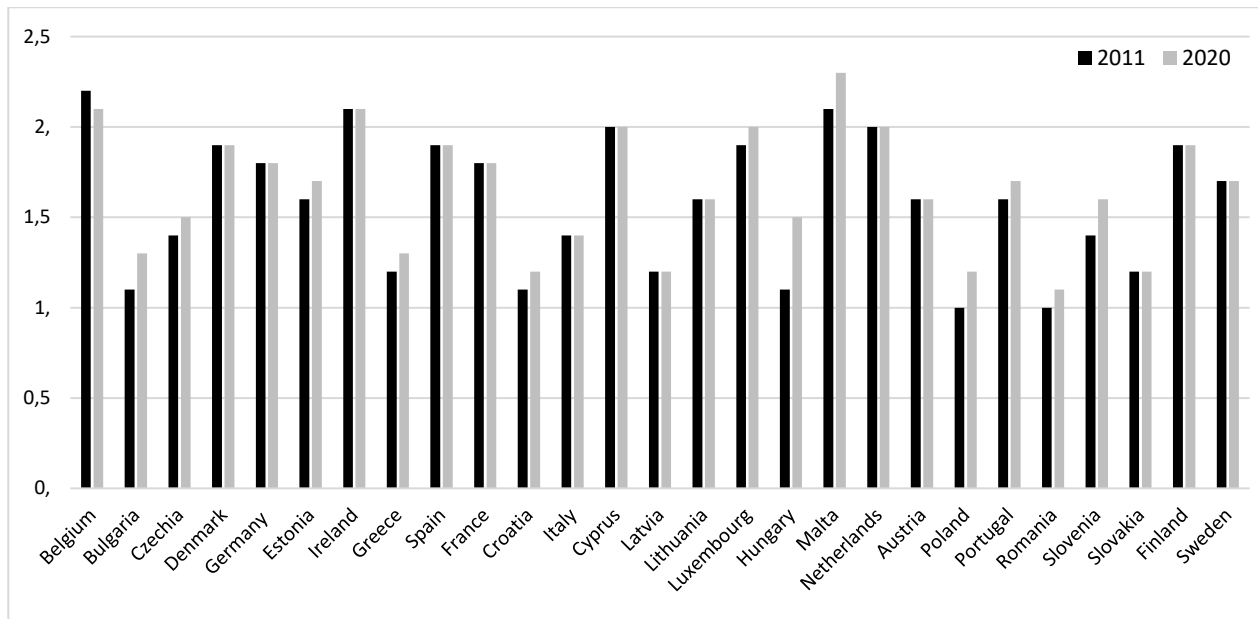


Figure 1. Number of rooms per person in European countries in 2011 and 2020

Source: Eurostat.

This implies the need to increase the efficiency of construction, in particular as regards the time and costs of implementation (two of many features of the structural distinctiveness of construction) in order to improve the housing conditions of the population.

Nowadays, developers in Poland are responsible for most completed dwellings. Real estate development activity consists in such transformation of real estate that its value is increased (Śmietana, Zagórska, 2009). Most often, this goal is achieved through the development of land. This, in turn, links real estate development activity closely with the construction market. The economic situation can affect the time of completion of specific real estate development projects and their cost, which was noticeable during the COVID-19 pandemic, and also now, as economies are trying to deal with its consequences. Rising inflation and higher interest rates are particularly problematic, as they increase the costs of running a business, including real estate development activity. High interest rates, combined with high housing prices, make it impossible for many households to buy their own dwelling. For developers, the rising costs of construction materials caused by the suspension of supply chains and the shortage of workers at the construction site were a significant obstacle already during the pandemic. It would seem, therefore, that developers will look for solutions in such a difficult situation to help them reduce investment costs, and at the same time

quickly meet the demand for dwellings. Modern prefabrication could be an effective tool to do so.

Therefore, the article aims to check whether Polish developers operating in the housing market use modern prefabrication to improve the construction process and what the economic benefits of using this technology can be achieved. The author states the hypothesis that the prefabrication technology will be more often used in housing construction than in previous years in view of the growing costs of construction and still high demand for apartments.

Literature review

In the 1970s in Poland, Prof. Goryński defined and characterized the features of the structural distinctiveness of the construction industry which cause a number of negative effects. These features have been divided into the objective and subjective ones according to the type of phenomenon to which they are related. They are characterized by interdependence, i.e. the subjective features of the distinctiveness of construction result from the objective characteristics in question (Goryński, 1976). Later, some scientists mentioned other, additional features proving this distinctiveness. The list of these features is presented in Figure 2.

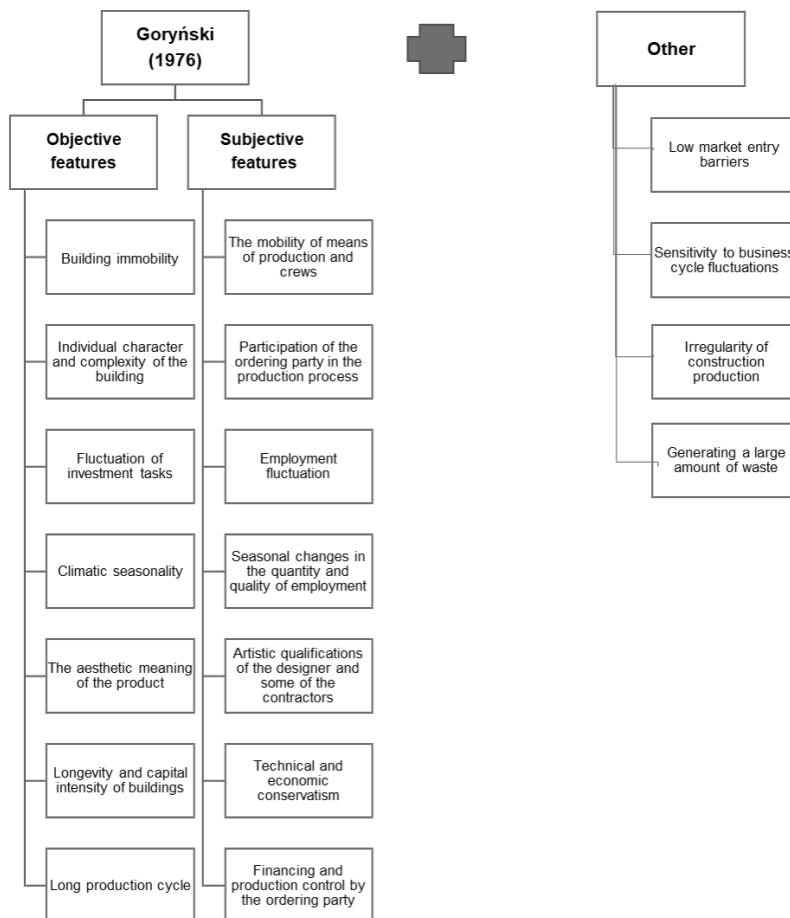


Figure 2. Features of the structural distinctiveness of construction

Source: own elaboration based on: Goryński, (1976), pp. 110-111; Rytel, (2009), pp. 159-171.

Interestingly, in the literature, there are considerations about the features that distinguish the construction sector from other sectors of the economy, but they are not of a comprehensive nature. For example, in 1988, Nam and Tatum distinguished five such features, i.e. immobility, complexity, durability, cost-effectiveness, and social responsibility of construction (Nam, Tatum, 1988). Therefore, the vast majority of these features refer to the object of construction activity, and not to entities that are parties to the investment process. The individual features listed in Figure 2 were also discussed, among others, by Chan and Xia (2011), Tschetter and Lukasiwicz (1983), Kabanda and Palamuleni (2011), Celadyn (2014), Antunes and Gonzalez (2015), and de Valance (2007).

All the above-mentioned features cause some negative effects for the construction industry as well as for real estate development activity. Building immobility means that a structure is

inextricably linked with the location indicated by the investor. Other products are manufactured in production plants, i.e. in places selected by the manufacturer (Puszko-Machowczyk, Bujak, 2011). The itinerant nature of construction is manifested in the necessity to transfer deposits, building materials and equipment from one construction site to another. This increases the transport intensity of the construction industry (Goryński, 1976). The individual character and complexity of buildings result from the expectations of a specific investor, the diversity of locations (see: Goryński 1976; Kucharska-Stasiak, 2016), the variety of designs, materials from which a given building is made, and the construction technologies used. This, in turn, requires monitoring of the construction process by appropriate entities with diverse knowledge and skills (Gidado, 1996). It should be noted that not all construction works may be performed in difficult weather conditions, e.g.: when it is wet, you should not do wet work

(pouring foundations, bricklaying or plastering). Particularly great difficulties in erecting buildings are visible in the northern countries, where permafrost occurs. There, during the thaw, the problem of soil subsidence and deformation of building structures often occurs (Streletskiy, et al., 2019). Low temperatures in general may preclude any work at the construction site due to the safety of employees, as such work may pose a danger of construction site disaster. Hence a decrease in employment in the construction industry is often recorded in the winter months (Tschetter, Lukaszewicz, 1983). This seasonal fluctuation of employment means that employees do not become attached to the workplace and the construction company owner does not care about their professional development.

Buildings are the most durable element of the space in which man lives, hence they affect not only one's living conditions but also the aesthetic experience (Goryński, 1976). This feature also seems to be particularly important due to the

longevity of building structures. The long-life cycle of buildings is the result of the fact that the materials they are made of wear away slowly (compare: Kanior, 2021; Flager, 2003). At the same time, they are created with a high share of the labour factor and costs, which often translates into caution in making investment decisions (Goryński, 1976). Moreover, the size of buildings, the variety of materials and technology used to construct them as well as sensitivity to climatic conditions make the work carried out "under the open sky" take longer.

Although the features of the structural construction distinctiveness characterized by Goryński (1976) were described already 50 years ago, many of them remain valid to this day. The negative effects of these differences increase the risk related to conducting construction activity. It is worth drawing attention, for example, to the number of bankruptcies in the Polish construction sector (Fig. 3).

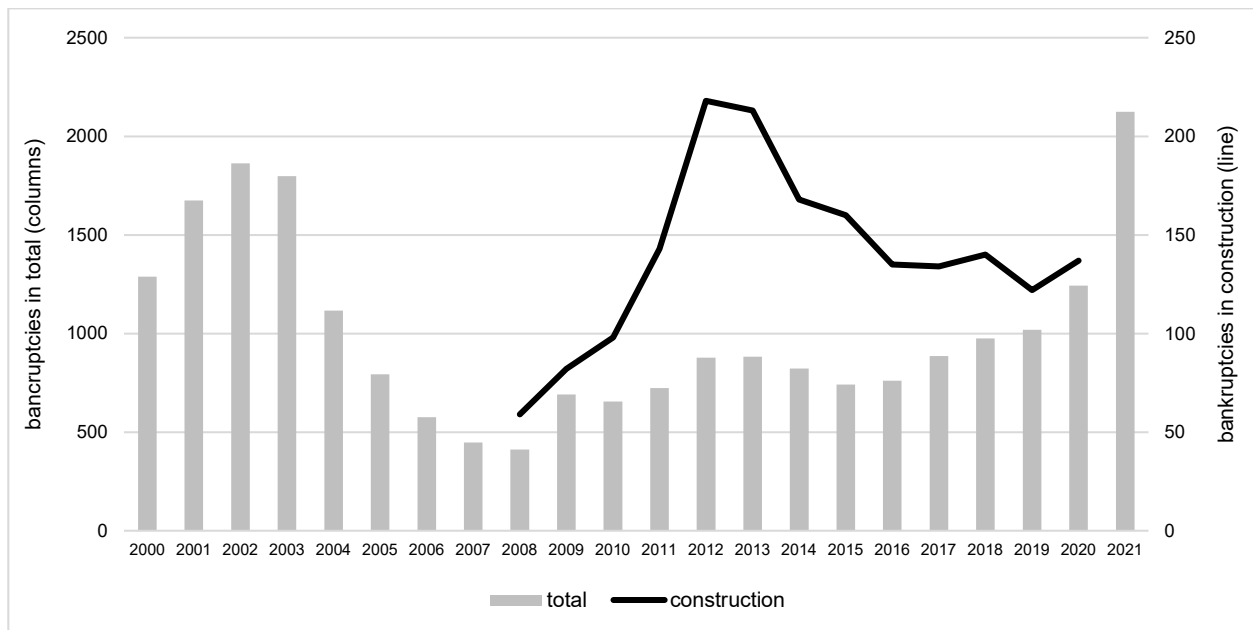


Figure 3. Number of bankruptcies in the Polish construction sector in the years 2000-2021

Source: own elaboration based on COFACE reports.

In a free market economy, there are additional features that indicate the specificity of construction. They include, among others, making the volume of construction production dependent on economic fluctuations. In the recession phase, buyers quickly stop making investments to satisfy their basic needs, but when the situation starts to improve, a wave of optimism that comes often turns into

"a herd instinct" leading to price bubbles (Żelazowski, 2007; Oust, Hrafnkelsson, 2017). Barriers to entry into the construction market are relatively low as the equipment can be hired and many workers are on fixed-term contracts. Moreover, the construction industry generates enormous amounts of waste and is energy-consuming (Rytel, 2009).

Four of the features discussed above: a long production cycle, capital intensity, irregular production and sensitivity to business cycles were visible during the COVID-19 pandemic and are visible now, when many world economies are still struggling with the negative consequences of the pandemic, including high inflation. The construction sector suffered significantly during the pandemic, as a result of the suspension of supply chains (Iqbal et al., 2021; Biswas et al., 2021; Umar, 2022; Ogunnusi et al., 2020), an increase in the cost of building materials (Adhikari, Poudyal, 2021; Alsharef et al., 2021), a shortage of workers, and thus an increase in wages in this sector (Majumder, Biswas, 2020, Timilsina et al., 2021). Due to bans on travel, remote work and a lack of materials, construction work was stopped or delayed altogether in some countries (Ogunnusi et al., 2020; Majumder, Biswas, 2020; Adhikari, Poudyal, 2021). There were also delays in Poland. Rising construction costs (in the traditional technology, which is the most popular) were associated with the need to raise the prices of dwellings as the final products of real estate development activity. Nevertheless, thanks to the low interest rates during the pandemic (0.1% - June 2020-September 2021), demand for real estate was high. Many new investments have been launched since that time, but due to the long implementation time, some of them will be commissioned in the coming quarters, and the current economic conditions do not encourage the purchase of dwellings anymore (inflation at the highest level since the 1990s and interest rates at the highest level since 2004). Therefore, it is worth considering tools that would help in eliminating at least some of these negative effects and make construction more effective, especially in the field of housing. One of such instruments may be modern prefabrication.

Prefabrication generally can be defined as mass production of building elements in a production plant which are then assembled at the construction site. Production is stationary, so it takes place regardless of climatic conditions and without specifying a particular recipient (Szruba, 2016). Moreover, when creating permanent workplaces, greater emphasis is placed on the quality of the work performed as well as the knowledge and skills of employees and their training. Foreign definitions of this process are slightly wider. Singhai (2015, p. 3) defines prefabrication as "building or structural components that are manufactured in industrialized/factory conditions and then transported to construction sites

to be assembled into a building, and civil engineering works. So, it is a process in that a whole structure or building or a component of it is completely fabricated at an offsite location" (compare also: Baghchesaraei, et al., 2015; Adamczewski, Woyciechowski, 2014).

As with any construction technology, modern prefabrication has its strengths and weaknesses. The most important strengths of this technology are:

- the possibility of standardization of building elements,
- repeatability of prefabricated elements,
- short delivery time – approx. 40% shorter than in the case of traditional technologies (Navaratnam, et al., 2019),
- manufacturing of prefabricated elements in production plants (Szruba, 2018) while carrying out works preparing the site for construction,
- lower exposure of materials and workforce to adverse weather conditions or other hazards,
- fewer term workers on site and lower overhead costs (Fenner, et al., 2017),
- reduced amount of construction waste and lower energy consumption (El-Abidi, Ghazali, 2015),
- reduced impact on neighborhood, including noise and dust (Navaratnam, et al., 2019).

Other strengths (compare Szruba, 2016; El-Abidi, Ghazali, 2015) of modern prefabrication technology identified and described in the literature depend on the type of construction material from which the prefabricated elements are made. Prefabricated construction also has its disadvantages, although there seem to be fewer of them than the advantages (see Szruba, 2018; Xiao, Proverbs, 2012).

Research methods

The desk research and case-study methods were used to check whether Polish developers operating in the housing market use modern prefabrication to improve the construction process and what the economic benefits of using this technology can be achieved.

Desk research allows for the use of secondary data or data that can be collected independently without conducting a field inquiry, e.g.: from Internet sources. This method is most often used when considering the size of markets, profiling companies and their products, and determining development trends (Hague, 2006). The case-study method can be understood as a comprehensive study of a given phenomenon, problem and person in their natural environment (Harling, 2012), e.g. in a market economy.

The empirical study was conducted in four stages:

- 1) first, the statistical data of the Central Statistical Office on the number of buildings commissioned in the prefabricated and large-block technology over the years 2013-2021 were analysed; above all, the years of the pandemic, in which more significant use of prefabrication technology was expected, were critical;
- 2) then, based on data from various real estate portals, press articles, and websites of individual developers, case studies of real estate development companies that implement multi-family housing using the discussed modern prefabrication technology were carried out.

These investments have been arranged in tabular form, taking into account similar information, i.e., the location of the investment, the total number of apartments in the investment, the number of flats sold (as of August 2022), the investment completion date, applied technological solutions and potential benefits indicated on the developer's website.

In addition, additional information from press articles on the benefits of using modern prefabrication technology has been analysed.

The research presented below focuses only on multi-family housing, as the use of prefabricated elements in Poland is already popular in commercial buildings and single-family housing.

The study covered the entire country, as there are relatively few investments in multi-family housing market built entirely with the use of prefabrication technology. These are investments on sale that have recently been implemented or are in progress. The collected data illustrate not only the popularity and diversity of the prefabricated elements used but also the benefits that have been achieved in a given investment thanks to their use.

Meaning of modern building prefabrication in Polish real estate development activity – results of analysis

Modern prefabrication is a common phenomenon in many developed countries, both in relation to commercial buildings and also to multi-family and single-family housing. For example, 84% of new single-family houses in Sweden was built in prefabricated technology, in Germany – 9%, in the Netherlands – 20%, in Japan – 28%, and in the United States – 5% (PAP, 2020). In France, 80% of multi-family buildings are currently built in prefabricated technology (TTS Development website, access: 8.08.2020). In addition, the economic

conditions caused by the COVID-19 pandemic (rising construction costs and rising housing prices) should encourage developers to use technologies whose main advantage is the possibility of reducing costs and investment implementation times. And, for example, in Germany, in 2020, a 4.9% increase in the number of dwellings constructed with the use of modern prefabrication technology was observed. In Italy, there is a growing interest in anti-seismic steel houses (Białas, 2021).

However, there are also countries with a developed real estate market where prefabricated construction is developing slowly. Australia is such an example (Steinhardt, Manley, 2016). In Poland, where the real estate market has only been developing for just over 30 years, after the period of centrally planned economy, modern prefabrication in multi-family housing is not yet popular, neither among developers nor among buyers. For example, in 2012, research was conducted among potential apartment buyers, which showed that the interest in new technologies in construction is limited (see: Radziszewska-Zielina, Gleń, 2014). And unfortunately, despite a relatively large scale of unfavorable economic phenomena caused by the COVID-19 pandemic (the highest inflation since the 1990s and the highest interest rates since 2004), an increase in popularity of this technology in housing construction was not observed. On the contrary, as shown by the data presented in Figure 4, despite the persistently high level of developer activity in the provision of housing, the number of multi-family projects implemented in the large-panel technology has drastically decreased.

It should be remembered, however, that modern prefabrication is a relatively new phenomenon when it comes to multi-family housing. Moreover, it is somewhat mistakenly associated with the socialist "big slab" and numerous technical flaws in building structures (Białas, 2021).

In addition, on the basis of selected real estate development companies, the scale of prefabrication used in multi-family buildings and its benefits were analyzed. A positive phenomenon is that the surveyed companies are constantly developing their activities. In November 2020, these enterprises carried out a total of seven investments advertised as those implemented in prefabricated technology (it is possible that not all developers "boast of" this fact for fear of lower apartment sales), while in August 2022 there were already 11 such investments.

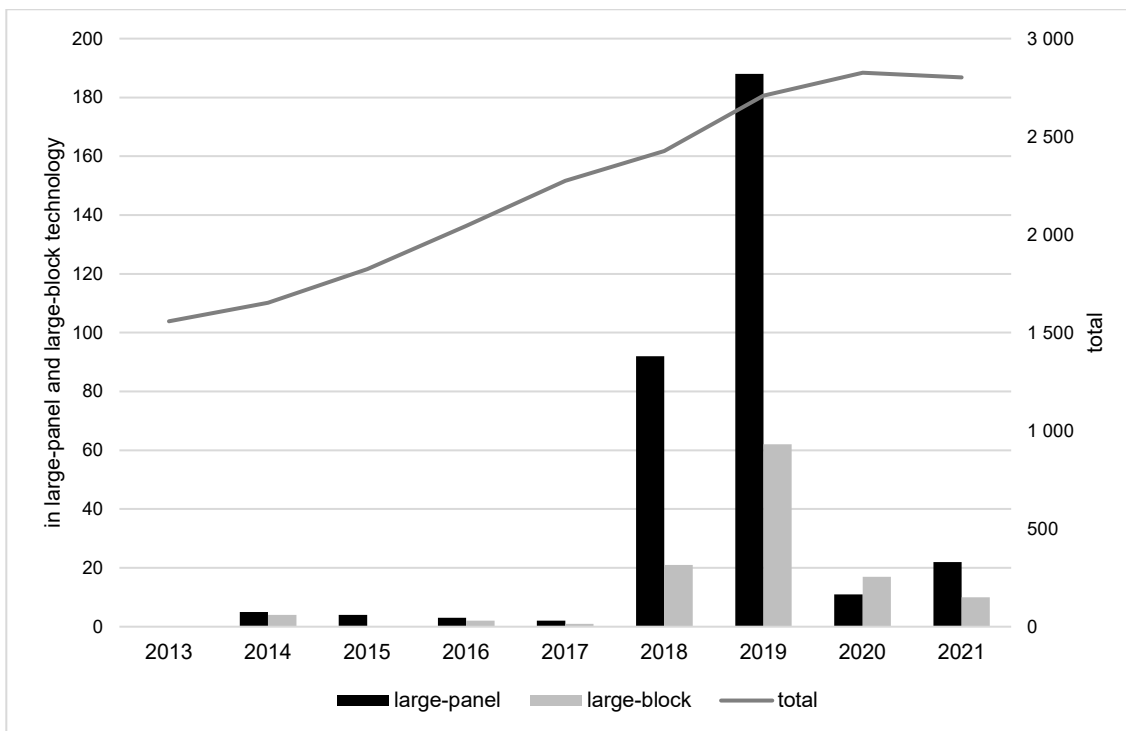


Figure 4. Number of new residential buildings completed by developers in Poland by construction technology
 Source: own elaboration based on the Local Data Bank of Statistics Poland.

Table 1 presents selected construction entities/developers using the prefabrication technology in multi-family housing and the solutions they use. The researched investments were located all over Poland. Among them, there are investments completed in years 2020 - 2022, and investments in progress with a completion date in 2023. The investments are also diversified in terms of size: small investments consisting of 12 apartments and large ones with over 200 apartments. The level of sales seems to be closely related to the timing of completion. The largest number of dwellings sold is in completed projects. Those scheduled for delivery in 2022 are roughly half sold out. This level appears to be quite low, although this may be due to factors other than the technology used, such as location. The solution used in the surveyed investments were also diversified. The problem is that it is not always possible to find information about the building technology used for the construction of a given building on the website in the case of developers dealing with multi-family buildings. Perhaps this is due to the concern about the attitude of potential buyers to the infamous prefabrication. Nevertheless, as shown in Table 1, a certain group of

Polish construction entities has been using this technology more and more often in the implementation of their investments. Some companies, other than mentioned in the Table 1, also emphasize that they have been using this type of solution for some time, but they limit themselves to using only certain prefabricated elements of building structures, such as stairs or balconies (Czy deweloperzy będą budować z prefabrykatów, 2020).

Identified cases of investments made of prefabricated elements indicate that such solutions ensure a shorter implementation period (Table 1), repeatability of the design (thanks to this, the individual character of building structures is eliminated) and high energy efficiency (Ecologia website, access: 8.08.2020). This shorter implementation time is due to the fact that several technological processes are carried out simultaneously, i.e. works related to pouring foundations and works on prefabricated elements in production plants, which are transported and assembled at the construction site immediately after the foundations have solidified. As a result, the construction process becomes less burdensome for the environment.

Table 1. Examples of Polish construction entities/developers using prefabricated technologies (August 2022)

	Location of investment	Time of completion	Number of dwellings	Dwellings sold	Solutions used	Advantages
Developer 1	Poznań	IIIQ 2023	124	24	Modular solutions	Construction time: 1 year
	Hel	IIQ 2023	68	15		Independence from the availability of materials and employees
	Warsaw	IIIQ 2022	40	30		High soundproofing and thermal insulation
	Mechelinki	IIQ 2022				
	Józefosław	IVQ 2021	12	12		
Developer 2	Pruszcz Gdański	IVQ 2021	200	188	One-, two- or three-layer wall elements, ceilings, stairs, landings, smoke and ventilation chimneys and others	Construction time: 8 months; freedom of shaping the function, body, and architectural form
Developer 3	Lublin	2022	241	117	French prefabrication system	Reduction of construction costs; simplification of the construction process; high quality of buildings and their functionality
	Legnica	2023	51	8		
	Chełm	2020	128	127		
	Dęblin	2021	40	33		
Developer 4	Warsaw	n/d	17	n/d	residential building made in the wooden frame technology	Construction time: 8 months, energy saving

* A system of "heavy" prefabricated elements, a large-panel system that was developed in France in the 1950s thanks to Raymond Comus, who patented this solution in 1948. The majority of the large-panel construction implemented in post-war Europe was based on it (<http://postwarbuildingmaterials.be/material/heavy-prefab-systems/>, access: 1.10.2020). Today's solutions, although still based on large-block elements, have been improved due to technological progress, and above all, connections and insulation.

Source: own elaboration based on Internet sources (as of August 2022).

Technical progress has contributed to increasing the durability of prefabricated objects, as well as to the improvement of their aesthetic values. Such buildings are also easy to expand by adding new modules (Climatic website, access: 8.08.2020). This is what seems particularly important from the developer's point of view. As shown by the data presented in Table 1, in investments of two construction entities, buildings were erected even within 8-10 months, so the investors recovered the funds involved faster. By using modern prefabrication, it is also easier to implement multi-stage investments or simply several investments at the same time in different places. It is all thanks to the fact that the construction site does not require as many employees as in the case of traditional technology. It also reduces the capital intensity of investments. In the investment of the Buszrem company from 2016, it was found that the construction-related costs were approx. 6.4% lower than in the case of investments implemented in traditional technology (Buszrem na fali, 2021). Therefore, it is an interesting alternative to time-consuming and capital-intensive (both in financial and human terms) developers' investments.

Discussion

The activity of entities that have decided to use modern prefabricated elements can be more efficient in relation to the duration of the investment and even construction costs (compare: Chavan, Desai, 2017; Xu, 2021; Rocha et al. 2023). In a situation of a significant shortage of dwellings in Poland, it seems to be imperative to implement such investments as soon as possible at lower costs. It seems to be justified, especially in recent years after the pandemic (2022-2023), when inflation and interest rates are at high level (in May 2023 CPI – 13% year to year, and reference interest rate at a level 6,75%; Central Bank of Poland 2023). Meanwhile, the share of buildings erected in prefabricated technology is surprisingly low (below 1% in 2021). One should consider the causes of this phenomenon. Is the bad opinion of the old prefabrication technology and the reluctance of the society to purchase apartments in such buildings the reason for it (the sales data contained in Table 1 do not confirm this)? Or is it due to developers' fears to use "novelties" in uncertain economic conditions?

Although the number of investments carried out by developers with the use of modern prefabrication technology has increased, other entities are not willing to get involved with what is an “unknown quantity.” Hence, both reasons imply a necessity to organize training courses: for developers to disseminate knowledge about modern prefabrication and good practices from abroad by organizations and associations strictly related to the construction and real estate development industry, and for society, which has a negative attitude towards this type of construction technologies. Without this, technical progress in Polish construction will proceed very slowly and the shortage of dwellings will decrease at a very low pace. However, there is hope that the fourth industrial revolution that is currently taking place (the fusion of technologies and machines) will contribute to the dissemination of this technology in construction, including multi-family housing (Białas, 2021).

Conclusions

To sum up, the aim of the article as indicated in the Introduction has been mostly achieved. The technology of modern prefabrication is not yet popular in Poland, but the entities using it see some economic benefits resulting from its use.

This article has contributed to the theoretical knowledge regarding the importance and application of modern prefabricated technology in multi-family housing construction in developing or post-socialist countries, though it has a bad reputation in the latter ones. Both the literature

review and the research carried out indicate the advantages and disadvantages of using modern prefabrication in the construction of multi-family residential buildings. Nevertheless, the former seem to be much more numerous, which has been an incentive for Western countries to implement investments with the use of prefabricated elements.

In Poland, there are not many new buildings made completely from prefabricated elements in the sector of multi-family housing. This is partly due to a lack of confidence in the “old prefabrication” technology due to bad post-war experiences. On the other hand, the lack of knowledge about modern prefabrication and the uncertainty of how these buildings will sell may also discourage developers from using this technology, although the benefits of using it should be a sufficient incentive. Lowering the time and in effect the costs of implementing development investments would result in an increase in dwelling sales.

By showing examples of entities that successfully use prefabricated elements in implemented investments, the article also provides practical value. The success of competitors is the best form of incentive for developers to use hitherto unknown technologies. Knowledge and good practices in this area may therefore constitute an impulse to increase the use of modern prefabrication technology by developers in multi-family housing.

As the use of technology based on prefabricated elements is growing year by year, it seems necessary to conduct further research in this area.

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